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Research Article

Response of Sugarcane Setts to Bio-Stimulant Solutions at Tillering Stage

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ABSTRACT

The study aims to determine the response of sugarcane setts to the different level of concentrations bio-stimulant solutions (BSS) that can accelerate the rooting and tillering. The study was conducted at UNO-R School of Agriculture, Philippines from October 15, 2023 -January 15, 2024. Phil 99-1793 variety is used. It was laid out in Completely Randomized Design with 4 treatments, replicated 4 times. The treatments were; no BSS (control), 200ml, 300ml, and 400ml BSS. Cane setts were prepared a day before planting. Leaf sheaths were remove and viable eye buds was selected. Setts were soaked in water for 24 hours and air-dried for 30 minutes before planting. The BSS were diluted in water before application. It was applied at plant base 15, 45, and 75 days after planting (DAP). Statistical analysis revealed highly significant on root weight and length with 110grams and 100.33cm for 400ml BSS, respectively. Great significant result also was observe for the tiller height at 30DAP and 60DAP with 26.10cm and 43.08cm respectively for 400ml BSS treatment. On tiller weight at 90DAP, number of tillers at 30DAP and number nodes at 90DAP statistics indicates a significant result with 752grams, 1.75tillers and 8.10nodes for 400ml BSS treatment. Application of 400ml BSS shorten the germination to only 5.30days while control treatment germinated at 8.03days. Application of 400ml BSS also increases the biomass with 4,310,00kg/hectare higher than the control with 2,242.50 kg/hectare. The study recommends the application of 400ml of BSS to accelerate the rooting and tillering of sugarcane setts up to 90DAP.

Keywords: *Bacterial sensing, Bio-stimulant, Drought tolerant, Microbiome, Root phenes, Root primordia, Tropism*

Introduction

Sugarcane (*Saccharum officinarum*) is one of the most important crop in the world because of its strategic position and immense uses in the daily life of any nation as well as for industrial uses aimed at nutritional and economic sustenance. It is cultivated on nearly 20 million hectares in more than 90 countries (Ullah et al, 2020). This crop belongs to the family Poaceae. A grass family that has properties

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much like that of wheat, maize, rice, and sorghum. The Poaceae family is globally vital for providing dietary macromolecules, carbohydrates, and different nutrients. The most important item for consumption is sucrose which accumulates in the stalk internodes.

Sugarcane is primarily cultivated for its juice, from which sugar is processed. Most of the world grows sugarcane in subtropical and tropical areas. The plant is also grown for biofuel production, especially in Brazil, as the canes can be used directly to produce ethyl alcohol (ethanol). The by-products from cane sugar processing, namely the straw and bagasse (cane fibers), can be used to produce cellulosic ethanol, a second-generation biofuel. Other sugarcane products include molasses, rum, and cachaca (Brazilian alcohol), and the plant itself can be used as livestock fodder. Sugarcane extracts and accumulates high amounts of soil nutrients, because it produces large amounts of biomass (da Silva et al, 2018).

The group of Oñal (2022) discussed in their book that the sugarcane plant is a delicate crop, and there is always need for plenty of fertilizer, irrigation, and a workforce that would work long hard hours of backbreaking labor without complaints or choices, as in the case of slaves. Long ago, the colonialists brought almost 12 million West Africans to the Caribbean in chains in the holds of slave ships during the four and half centuries, which was between 1450 and 1900.

The production process for sugar was so exciting, and the slaves lived and worked in unspeakably difficult conditions. They spent weeks on end in the fields, bent over at the waist, hacking away the razor-sharp machetes at the tough stalks, some as tall as 20 feet.

After harvesting, the hauling of cane to the mill follows without any delay, where it was ground through rollers to extract the precious juice. Laborious cooking in a witch-type cauldron followed, and had be tender round the clock. Timing was of the essence because the cane juice spoils quickly. After the extraction, pouring of juice into molds follows, with the excess drained off to form molasses. For processing shipping of hardened bricks of raw sugar to Antwerp or London refineries. In the Philippines, there is an absence of trading the slaves. However sugar industry here has its unique history of exploitation, excitement, and human drama. Nowhere in history can illustrate the industry in the province of Negros Occidental which is located between the islands of Panay and Cebu in the Visayas. Sugarcane still as a subsistence crop grown long before exporting it. Nicholas Lonney, a British businessman, was the first to recognize its potential as an export crop. In the 1850's he brought in the machinery for sugar production. Originally based in Iloilo, the rich mestizo businessman soon migrated to nearby Negros Island to take advantage of the fertile land and large "indio" workforce.

In an early form of globalization, the opening of Visayas ports (Iloilo and Cebu) and the introduction of sugarcane as a lucrative cash crop changes everything. By the 1860s, Negros Occidental is the leading sugar-producing province in the Philippines, known also as the "sugar bowl of the Philippines". The Filipino people are very resilient, and there are few promising signs. Filipino women in particular can show amazing strength.

When sugar's house of card (casino game house) came tumbling down in the 1970s, and 1980s, many women raised from elite families were in the lap of luxury. The women who were used to shopping junkets in Hong Kong and playing mahjong on the veranda were with financial devastation. A significant minority of them turned to small-scale handicrafts. In many cases, their effort saved their family farm. Such small-scale diversification in the economy has made some dent in the troubling economic trends. However, the modern-day reality is that the Philippines' sugar industry continues to face staggering indebtedness and serious questions about its long-term viability. Take a trip to Negros today and you may well fellas, if you are in a time warp. "sacadas" (migrant field workers), wear droopy clothes and headgear to protect themselves from the searing sun, with just slit open for their eyes.

Steam engines, known affectionately as "iron dinosaurs," meander their way through the cane fields, mechanical caterpillars out of place and out of time, and it is not very hard to transport oneself back to the colonial era. They symbolize the antiquity and general noncompetitiveness of the Philippine sugar industry as it stands today.

Like any other ASEAN country, the Philippine sugar industry was not so prepared until the impact of 2015. As a result, the industry has now identified what to do. It must implement appropriate programs and interventions to address the threats and exploit the opportunities of trade liberalization, especially in the delivery of modern agricultural extension services.

Philippine sugar statistics show that there are more than 80,000 sugar farmers in the whole country in the year (SRA, 2022). The total area harvested was 418,215 hectares for Crop Year 2017-2018 and down to 394.637 hectares only in Crop Year 2021-2022 (SRA 2022). The average sugar yield in terms of LKg/hectare was 99.64 LKg/ha in Crop Year 2017-2018 and decreased to only 92.28 LKg/ha in Crop Year 2021-2022. In terms of the total volume produced in Metric tons, it was 2,083,641 in Crop Year 2017-2018 decreasing to 1,820,863 in Crop Year 2021-2022, respectively. The Philippine Statistic Authority (2023) data on the volume of production for the period April- June 2023 was 2,829,318.22 metric tons (preliminary data). World Bank (2021) as cited by Oñal in his book (2021) reported that the value shares had been declining for sugarcane in the fifteen regions in the Philippines, except for Region Vl (Western Visayas), which suggests increasing specialization for the crop. The share value output of sugarcane in the three regions in Visayas, were; 16.1%, 5.6%, and 0.9% in Regions Vl, Vll, and Vlll, respectively.

The self-prepared bio-stimulant solution use in this study. Bio-stimulant is a mixture of various beneficial microbes. They protect plants from various fungal and bacterial pathogens. Bio-stimulant improves crop protection and helps in crop yield if applied at regular intervals. It is a compound mixture composed of more than 80 microorganisms in 10 genera, including lactic acid bacteria, photosynthetic bacteria, actinomycetes, and yeast. It has a positive effect on soil deterioration, continued cropping obstacles, crop disease resistance, yield, and quality. Recent studies emphasize the importance of fostering a diverse and functionally active soil microbiome for optimal decomposition and nutrient cycling. This can be achieve through practices that promote beneficial microbial populations, like reduced tillage and organic amendments (Philippot et al, 2019).

Bio-stimulants are a mixture of hormones as well with different plant regulators or with nutrients that can provide better performance for plants. The presence of plant hormones promotes vital and structural changes in the plant. Thus, there will be better cellular development and tissue growth. Objectively, organs such as leaves, stems, and roots can develop in larger sizes and numbers reflecting the plant's production potential. The biggest potential production joining with the available nutrients can promote a greater effect on the productivity of crops such as sugarcane (Moraes et al, 2018).

The use of bio-stimulants in sugarcane crops can increase yield and quality components. However, the study of the group of Santos (2020) shows that bio-stimulant did not increase the tillering component of the sugarcane plant. This research anchored on the theory of microbial inoculants in Agriculture: Niche Competency Theory. Introducing beneficial microbes acts like a turf war in the soil. These helpful microorganisms claim essential resources and space, leaving less for harmful pathogens to survive. As a result, the harmful microbes struggle to grow and infect plants, ultimately protecting their health (Buyer and Munakata-Lorenz, 2019).

Tillering is a cultivar characteristic, and as many as 350,000 tillers per hectare have been observe in South Africa on ratoon NCo376 before full canopy. However, only about 155,000 tillers survive to harvest in NCo376, whereas other cultivars with higher sucrose tend to have a lower stalk population at harvest of 90,000 to 120,000. The final stalk population varies with cultivar, climatic conditions, and stage of ratoon (smaller stalk weight and a higher population with successive ratoons).

High light intensity and an increase in temperature to 30^{o}C tend to favor tiller development. Water stress reduces tillering. Side shoots may occur when irrigation resumed. Damage to the growing point (e.g. from hail, frost, or chemical ripeners) reduces apical dominance and increases the development of lower tillers and side shoots.

Tillering is relate to the phenomenon of “apical dominance” and, therefore, plant hormones are involved in the process of tillering. The most important external factors influencing tillering are light, temperature, nutrition, moisture, and the spacing of the planting. These factors and experiments have shown that light is the most significant. Increasing light intensity and duration, in general, greatly increases tillering. In young cane fields, the period of profuse initial tillering is follow by a wave of mortality as soon as the rows close. Mire that 50% of the number of the initial stalks made. Much of the mortality is due to light competition. (Sandhu et al, 2019).

Sugarcane root systems are poorly study as well as hard to understand due to their perennial nature, tall structure, and long cropping cycle. Whilst some field studies give insights into sugarcane root traits, there is no detailed description of root and root system traits available. The result shows that the number of tillers as well as the total of developed leaves is significantly different among varieties and ranges from 3.0 to 11.7. Similarly, the total root length was highly significant among varieties and ranged from 0.65m - 5.60m of root length with an average of 2.83 meters of root length per plant. The study of the group of Gomez-Koskey (2019) indicates that sugarcane fresh weight of roots, number of roots, and length of the longest root had a superior result with the applications of two bio-stimulants they studied, with significant differences to the control.

The group of Kumalaw (2021) cited in their study that the growth hormone of young coconut water which was used as a bio-stimulant, was applied on the bud chip of sugarcane seedlings had a significant effect on root volume, leaf area, fresh weight, and dry weight of roots and tops of sugarcane at the age of 40-120 days after planting. Sugarcane plants with the entire root system had higher root content of starch, soluble sugar, and nonstructural carbohydrates as compared to plants with 50% of the root system. A significant positive correlation was find between the variation of shoot dry mass and the variation of root nonstructural carbohydrates. Interestingly, this data revealed a disproportionate effect of root system size on sugarcane regrowth, with plants with the entire root system accumulating almost three times more biomass than plants with half of the root system during regrowth (Pissolato et al, 2021).

This study on the response of sugarcane sugarcane setts applied with different levels of concentration of Bio-stimulant solutions aims to contribute to the pool of knowledge on the study of plant physiology, root architecture specifically on sugarcane, phototropism, and gravitropism of the above-mentioned crop.

Furthermore, it also aims to identify the growth relationship between the roots and tillers of the crop. Knowing the relationship between the two variables will be a good guiding tool for all stakeholders especially on the propagation of planting materials or in the establishment of a propagation nursery for new or high-yielding varieties.

This study also aims to contribute also to the field and body of knowledge on natural farming, agro-ecology, and root physiology of the plant.

General Objective

The general objective of this study is to determine the response of sugarcane setts to the application of bio-stimulant solutions at different levels of concentrations at 90DAP.

Specifically, this study aims to

1. Determine the response of the application of different levels of concentrations of bio-stimulant solutions in enhancing the tillering as well as the number, length and weight of the tillers of sugarcane plant.
2. Determine the response of the application of different levels of concentrations of bio-stimulant solutions on the rooting capacity including the length and weight of the roots of sugarcane plant.
3. Determine some critical growth characteristics of sugarcane crops that will correlate to the formation of root and tillers when applied with the different levels of concentrations of bio-stimulant solutions.
4. Establish some primary characteristics of roots and tillers of sugarcane plants that can be observe as a determinant in accelerating the growth of selected varieties, especially for nursery establishment.

Materials and Methods

Materials

The variety used was Phil 1999-1793 (Phil 93-236-3301 x Phil 8477). Its habit of growth is erect, a fast grower variety, and has medium size stalk. It is drought tolerant variety. Its potential yield is 170.69 tons cane/hectare with an average sugar rendement of 2.12 LKg/TC.

Experimental Design and Treatments

This study employed Completely Randomized Design. The four (4) levels concentrations of bio-stimulant solutions as treatments including the control and were replicated four (4) times. Data were gathered from five (5) sample plants per replication

The Treatments:

T1 – control (no BSS)
T2 - 200 ml BSS
T3 – 300 ml BSS
T4 – 400 ml BSS

Cultural Management

Preparation of polyethylene bags and planting materials

1. The experimental area of 100 square meters was cleaned and leveled off.
2. Around 80 polyethylene bags were filled with garden soils as planting mediums.
3. After filling up with soil, the p-bags were laid out in the area as per the treatment design
4. Soil samples were taken from each polyethylene bag for analysis.
5. Around 100 pieces of 2-eyed cane points of Phil 99-1793 were used as planting materials
6. The cane points were soaked in water for at least 24 hours.
7. Soaked cane points had undergo the air-dried process for at least 30 minutes.
8. One cane sett was planted in each polyethylene bag.

Weed management

1. Hand weeding was done before the application of bio-stimulant solutions and/or as the need arises.

Water management

1. Sufficient quantity of water were provided to maintain the moisture content of the soil.

Pest and Disease Control

1. The area was regularly monitored for the presence of pests and diseases. The researcher conducted a dailyvisits and monitor the presence of the same.

Preparation and application of bio-stimulant solution

1. Preparation of bio-stimulant solution was done separately per treatment before its application.
2. The bio-stimulant were prepared by pouring the pure BSS in a glass beaker and diluted with mineral water.
3. At the field, a plastic measuring cup was used for even distribution of the solution.
4. The solution were poured at the based of each plant.
5. Succeeding application of bio-stimulant solution was applied at 15, 45, and 75 days after planting.

Research Environment

The experiment was conducted at the UNO-R School of Agriculture Field, Bacolod City, Philippines last October 15, 2023 to January 15, 2024.

Data Gathered

The following data were gathered as per protocol:

1. *Period of germination* (in number of days)
2. *Height of tillers* (in cm) taken 30, 60, and 90 days after planting (DAP).
3. *Number of tillers* taken at 30 DAP, 60DAP, and 90DAP.
4. *Number of nodes* taken at 90DAP.
5. *Length of leaves* (in cm) taken 90DAP.
6. *Weight of tillers* (in cm) taken 90DAP.
7. *Weight of roots* (in grams) taken 90DAP.
8. *Length of roots (in cm)* taken 90DAP.
9. Total *biomass* in (kg/hectare) taken 90DAP.

Statistical Analysis

All data gathered were statistically computed, and subjected to Analysis of Variance (ANOVA) in CRD using STAR 2.0.1.

The Least Significant Differences (LSDs) were used to determine significant differences among treatments.

The size and thickness of cane points also relate to food reserves of planting materials. The thickness of cane points is known to provide 5% more germination than the thin ones. The 2-3 eye-bud cane points will give more germination compared to the one-eye bud setts (Singh et al, 2019).

Tiller Height (cm)

Table 2 revealed the average height of sugarcane tillers applied with different levels of concentration of bio-stimulant solutions at one-month intervals. The data were gather at 30 days after planting (DAP), 60 DAP, and 90 DAP. Results show that tillers' height was highly significant at 30DAP and 60DAP, and was significant at 5% level only during the 90DAP, respectively.

At 30DAP, the table shows that T4-400ml BSS had the highest average tiller height of 26.10 cm. T3-300ml BSS followed with 22.78 cm while there is no significant difference among means of T2-200ml BSS and T1-no BSS with 15.15 and 13.48 cm, respectively.

At 60DAP the table shows that there is no significant difference among means of T4-400ml BSS and T3-300ml BSS with an average height of 43.08cm and 41.90cm, respectively. Furthermore, the results also show no significant difference among means of T2-200ml BSS and T1-no BSS with 32.05cm, and 27.60 cm, respectively.

After the 60DAP, the result further indicates that means of T4-400ml BSS and T3-300ml BSS have no significant difference in height with 43.08cm and 41.90cm, respectively. However, at 30DAP T4-400ml BSS had a taller height of 26.10cm which is very significant with that of T3-300ml BSS with 22.78cm only.

At 3 months or 90DAP, the elongation process of tillers is still significant. The results indicate that there is a comparable result between the T4-400ml BSS and T3-300ml BSS with 95.65cm and 92.30cm, respectively. Treatment means of T2-200ml BSS and T1- no BSS also indicate comparable result with 64.90cm and 53.75cm, respectively.

Results show that the application of bio-stimulant at higher concentrations can enhance the tillering of sugarcane plants even up to 90DAP, which numerically tripled when compared to 30DAP. The group of Shandu in 2019 discussed that cane growth does not proceed at a uniform rate. Normally the growth starts slow at the germination phase but it increases until a maximum height is reached. The period in which the sugarcane plant is growing rapidly was called as the "grand growth period." Rapid elongation usually occurs with the correct temperature mean of 18.5C^0. It will continue to grow or elongate rapidly under warmer conditions between 1 to 2 cm/day (Meyer et al, 2011).

Bio-stimulants are products that can increase plant growth (Vasconcelos and Chaves, 2019). They discussed further that in small concentrations, these substances are efficient and favor the good performance of the plant's vital process, to wit: enhancement of the height of sugarcane.

Number of Tillers

The average number of tillers per sugarcane cane points planted as applied with the different levels of concentrations of bio-stimulant solutions presented in Table 3. Data were gather at 30DAP, 60DAP, and 90DAP. Specifically, a significant number of tillers that emerged among treatments was observe at 30DAP, it ranges from 1.60 to 2.00 tillers per cane point planted. T1-no BSS shows the highest number of tillers that emerged with an average of 2.00 tillers, followed by T2-200 ml BSS, T4-400ml BSS, and T3-300ml BSS with 1.80, 1.75, and 1.80 tillers per cane setts planted, respectively.

However, at 60DAP the statistics showed that there was a comparable result among treatments. Numerically T4-400ml BSS and T3-300ml BSS had the same number of tillers at an average of 2.05 per cane sett planted. The number of tillers for T2-200ml BSS and T1-no BSS did not increase as compared to the result taken at 30DAP, which has a 1.80 and 2.00 tillers per cane point, respectively.

At 90DAP, the number of tillers had increased but there is no statistical difference. All treatments had increased the number of tillers numerically.

The results of the study indicate that applications of different levels of concentrations of bio-stimulant solutions have a minimal effect on the number of tillers produced by cane sett.

The result of this study agrees with the findings of the group of Santos (2020). According to the group, the use of bio-stimulants solutions can increase sugarcane yield and other quality components but it does not increase the tillering of the sugar plant.

The group of Rai (2020) commented that sugarcane farmers increasingly turning to eco-friendly bio-stimulants to boost yield and plant health. They further discussed that bio-stimulants do not add nutrients but instead wake up natural processes inside the plant, leading to several benefits.

The build-up in the shoot population or number of tillers during the early establishment phase is refer to as tillering. It is a cultivar characteristic. Tillering is relate to the phenomenon of "apical dominance" and therefore, plant hormones are involved in the process of tillering. Relatively some of the external factors that influence tillering are light, temperature, nutrition, moisture, and the spacing of planting. Foremost among those is the light (Sandhu et al, 2019).

Number of Nodes, Length of Leaves (cm) and Tiller Weight (gm)

Table 4 presents the three variables taken into consideration by this study, namely: the number of nodes, the length of the leaf, and the weight of the tillers taken 90DAP.

Results revealed that the applications of different levels of bio-stimulant solutions had significantly influenced the production of nodes and the weight of tillers of sugarcane taken at 90DAP. However, it does not increase the length of the leaves in the same period.

Individual discussions of the three variables is presented here under.

Number of nodes

Results in Table 4 further show that applications of bio-stimulant solutions at different levels of concentrations enhances the number of nodes per tiller of the sugarcane plant. The number of nodes was observed to be higher in T4-400ml BSS and T3-300ml BSS with an average of 8.10 and 7.30 nodes per tiller, respectively but the average means are comparable. Comparable result was observed also between T3-300ml BSS and T2-200 ml BSS with 7.30 and 6.00 nodes per tiller. Likewise, comparable result also observed also between T2-200ml BSS and T1-no BSS with 6.00 and 5.20 nodes per tiller.

The nodes are where the leaf attaches to the stalk. This is a portion of where the eye buds and root primordia be found (Sugarcane Botany, 2019). The number of nodes of plants including the sugarcane is controlled mainly by the genetic characteristics of a cultivar, though it may also affected by growing conditions. For sugarcane, the average number of nodes that can produced is 3 to 5 per month. The study of the group of Munsif (2018) shows that some substantial differences were recorded for the number of nodes per tiller especially for those planted in November which have a high number of nodes while March produced less number of nodes. Under conditions of continuous growth, more than 30 nodes can be produce in a year per stalk. Relatively, the stalk can grow more than 3.5 meters (Meyer et al, 2011).

Length of leaves (cm)

The length of sugarcane plants as applied with different levels of concentrations of bio-stimulant solutions is also shown in Table 4. Results show that leaf length is not influence by the applications of bio-stimulants at different levels of concentration. Numerically however, T4-400ml BSS and T3-300ml BSS had produced the longest leaves at 90DAP with 43.08cm and 41.90cm, respectively.

However, the study of the group by Gomez-Kosky (2019 shows that the application of two brands of commercial bio-stimulants in the in-vitro (tissue culture) production of sugarcane plants in both planting seasons shows a greater number of leaves and leaf length, which caused an increase in the content of chlorophyll and therefore high photosynthetic activity.

Weight of tillers (gm)

Tiller weight as influenced by the application of different levels of concentration of bio-stimulants solutions taken at 90DAP is presented as well in Table 4. Results indicate that the application of different concentrations of bio-stimulants solutions has a significant effect on the weight of tillers. T4-400ml BSS has an average weight of 95.65kg, followed by T3-300ml BSS with 92.30kg, respectively. However, no significant differences were observe, between T4-400ml BSS and T3-300ml BSS with 95.65kg and 92.30kg, respectively. Comparable result is also observe between T2-200ml BSS and T1-no BSS with 46.90kg and 53.75kg, respectively.

The build-up in the shoot population during the early establishment phase is refer to as tillering. The germinating buds produce primary tillers, which are the oldest shoots. The secondary tillers grow from the primary and the tertiary from the secondary shoots. At full canopy, when full leaf-ground cover is achieve shading out of the smaller tillers occurs and they start dying. (Sandhu et al, 2019)

High light intensity and an increase in temperature to 30°C tend to favor tiller development. Water stress reduces tillering. Sideshoots may occur when irrigation is resume. Damage to the growing point (e.g. from hail, frost, or chemical ripeners) reduces apical dominance and increases the development of lower tillers and side shoots.

The group of Kumalaw (2021) cited in their study that the growth hormone of young coconut water which was used as a bio-stimulant had a significant effect on root volume, leaf area, fresh weight, and dry weight of roots and tops (including the weight of tillers) of sugarcane at the age of 40-120DAP. They applied the bio-stimulant on the bud chip of sugarcane seedlings.

Weight (gm) and Length of Roots (cm)

The average weight (in grams) and the length (in centimeters) as influenced by the application of different levels of concentrations of bio-stimulant solutions is presented in Table 5.

Root weight and root length are significantly influence by the application of different levels of concentrations of bio-stimulant solutions.

Table 5 shows that at 90DAP T4-400ml BSS has an average weight of 110.00grams, followed by T3-300ml BSS with 97.00grams, respectively. However, no significant differences were observe, between T4-400ml BSS and T3-300ml BSS with 100.00grams and 97.00grams, respectively. The same result is also shown between T2-200ml BSS and T1-no BSS with 75.65grams and 74.75grams, respectively.

Table further shows that at 90DAP the root length has significant difference among the 3 treatments including the control. Relatively, T4-400ml BSS has the longest roots with 100.33cm with a difference of 21.3cm from T3-300ml BSS with 79.03cm only. T2-200ml BSS has the third longest length with 70.63cm, and T1-no BSS has a 63.33cm average root length, respectively.

The study of the group of Gomez-Koskey (2019) indicates that sugarcane fresh weight of roots, number of roots, and the length of the longest root had a superior result with the applications of two bio-stimulants they studied, with significant differences from the control.

The sugarcane root system is fibrous and shallow but develops buttress roots that serve to anchor the plant. Under rain-fed conditions in deep and sand clay-loam soils, buttress roots have the potential to penetrate to depths of 5 to 7 meters, allowing for water absorption under stress. The below-ground shoot and root from a single node develop over time into a stool (a conglomeration of roots and shoots, Meyer 2022).

The function of the root system is two -fold: first, it enables the intake of water and nutrients from the soil; and second, it serves to anchor the plant. Two kinds of roots will develop from planted seed pieces. The set roots arise from a planted seed piece. The set of roots will develop from a planted seed piece. The shoot roots, originating from the lower root bands of the shoots, are thick, fleshy, and less branched. Before shoots form, the germinating seed piece must depend entirely on the set roots for water and nutrients.

The set of roots, however, is only temporary, and their function will eventually be taken over by the shoot roots as they develop. The life of the shoot root is also limited. Each new tiller (shoot) will develop its roots that eventually take over the function of the original shoot root.

This rejuvenation, governed by the periodicity of tillering, is important because it allows the plant to adjust to changing environmental conditions (Sugarcane Botany 2019).

The root system is both dense and deep. That is why sugarcane protects soil efficiency notably against erosion due to heavy rain and cyclones (CIRAD, 2023).

A longitudinal section of a root tip consists mainly of four parts, the root cap, the growing period, the region of elongation, and the region of root hairs. The root cap protects the tender tissues of the growing point as the root pushes through the soil. The growing point consists mainly of an apical meristem, where the cell division takes place in the region of elongation, the cells increase in size and diameter until they reach their ultimate size. The region of root hairs is characterized by epidermal cells forming outgrowth (hairs) that dramatically increase roots root-absorbing surface. (Sandhu et al, 2019).

Biomass (kg/hectare)

Biomass is taken by measuring the dry weight of organic matter produced. It is the weight of living plant material contained above and below the unit ground surface area, at a given point in time (Roberts and Bealde, 1985). Table 6 clearly reveal the results of total biomass in kilograms per hectare, which was gathered at 90DAP.

The results show that the application of different levels of concentrations of bio-stimulant solutions on sugarcane plants influenced the production of biomass. Specifically, the results indicate that there is a comparable result between the T4-400ml BSS and T3-300ml BSS with 4,310.00kg/ha and 3,817.50kg/ha, respectively. The same observation was shown between T3-300ml BSS and T2-200ml BSS with 3,817.50kg/ha and 2,338.50kg/ha, respectively. Relatively no comparable results were revealed between T2-200ml BSS and T1-no BSS with 2,338.50kg/ha and 2,242.50kg/ha, respectively.

Sugarcane plants with the entire root system had higher root content of starch, soluble sugar, and nonstructural carbohydrates as compared to plants with 50% of the root system. A significant positive correlation was found between the variation of shoot dry mass and the variation of root nonstructural carbohydrates. Interestingly, this data revealed a disproportionate effect of root system size on sugarcane regrowth, with plants with the entire root system accumulating almost three times more biomass than plants with half of the root system during regrowth (Pissolato et al, 2021).

The study of the group of Gomez-Koskey (2019) indicates that sugarcane fresh weight of roots, number of roots, and length of the longest root had a superior result with the applications of two bio-stimulants they studied, with significant differences to the control. The group of Kumalaw (2021) cited in their study that the growth hormone of young coconut water, which was used as a bio-stimulant, was applied on the bud chip of sugarcane seedlings. They further discussed that there is a significant effect on root volume, leaf area, fresh weight, and dry weight of roots and tops of sugarcane at the age of 40-120 days after planting. Growth hormones are also present in various bio-stimulant products. Commercial bio-stimulants contain growth hormones consisting of auxins, cytokinins, and gibberellins. Bio-stimulants are complex substances containing plant growth-promoting -substances and can increase shoot and root growth.

The study of the group Lovera (2021) assessed the development of sugarcane root systems as an influence of different soil tillage systems and cover crops for three cycles. The results show that during the first three sugarcane cycles, the 0.0 – 0.2 meters depth surface layer concentrated the highest amount of dry biomass of roots. It represents between 36% and 62% of roots in the first 0.6 meter deep.

Correlation of Selected Characteristics

The competency of associating between characteristics provides the strength of a linear relationship between two parameters and helps identify the most important characteristic (s) is to be considered in determining possible phenomena of ineffective characterization. In this simple study, it is important to obtain information on the relationship between growth determinants and accelerating the formation of roots and tillers including their length.

As a backgrounder, the roots of sugarcane could serve as reference on the genetic variability among sugarcane plants that can partially explain the acceleration of their formation including the tillers on the above ground. By understanding, the growth and formation of roots and tillers especially the factor that enhances their formation, the challenges in the production of selected planting materials (especially, if the number of materials is limited) for the establishment of a nursery will be well managed by the farm administrators and/or farmers.

Relatively, the roots serve as the primary factor in the survival, development, and performance of any plant including sugarcane. It is because the above-ground parts including the tillers, number of nodes, tiller weight, and numbers among others, depend on it for anchorage and absorption of water and nutrients including the bio-stimulant that was used in this study.

Correlated Characteristics with Root Length of Sugarcane Plant

Among the characteristics tested for correlation with root length 5 are found to be positively correlated while 1 is negative as shown in Table 7. Positive linear correlation is the root weight with an r-value of 0.79 and is correlated strongly with root length. Biomass, germination period, tiller height, stalk weight, and number of nodes were moderately correlated with the length of the roots, with an r-value of 0.58, 0.60, 0.56, and 0.68, respectively. On the other hand, days of germination have a negative correlation with an r-value of -0.89.

Table 7 also indicates, that the visible characteristics on the above-ground parts of sugarcane that can be correlated with root length, are the number of nodes (r-value=0.68) and tiller height (r-value=0.60).

Correlated Characteristics with Tiller Height Sugarcane Plant

Among the characteristics tested for correlation with the height of the tillers, 5 are found to be positively correlated while 1 is negative as shown in Table 8. Among the positive, the number of nodes is strongly correlated with height of the tillers with r-value of 0.95. Biomass, stalk weight, root weight, and root length are all moderately correlated with the height of tillers, with an r-value of 0.90, 0.90, 0.63, and 0.60, respectively. On the other hand, days of germination have a negative correlation with an r-value of -0.57. Relatively, the underground characteristics that can be correlate with tiller height are the root weight (r-value=0.63) and root length (r-value=0.60).

The expansion of sugarcane production areas is limited, hence, the improvement of yield components of sugarcane might be a strategy to enhance cane production. The group of Khonghintaisong (2020) studied to identify the relationship between roots in each tiller and their above ground parts during the tillering phase. The results showed that there was a positive correlation between the sum of the roots in all tillers per hill and the dry weight of shoots.

Furthermore, they observed that root traits of individual tillers, for almost all cultivars tested including root volume, root surface area, root length, and root numbers were positively correlated with biomass and stalk weight except for one cultivar. They concluded that the root characteristics that can potentially be used as criteria to assess tillering performance. Relatively, in contrast, the root-to-shoot ratio may not be an appropriate characteristic to assess shoot growth, and dry weight varied among cultivars that they tested.

Conclusions and Recommendations

The different concentrations of bio-stimulant solutions accelerate strongly the formation of roots and tillers of sugarcane setts. The use of 400ml bio-stimulant significantly influenced the rate of germination, tiller height, number of nodes, weight of tillers, weight of roots, length of roots, and biomass. Based on the findings, this study recommends the use of 400ml bio-stimulant solutions as its response strongly in the formation of roots and tillers of sugarcane setts.

For correlated traits, the height of the tillers is influence strongly by the number of nodes and stalk weight. Hence, this study recommends that in selecting planting materials for propagation or establishment of the nursery, high tillering cane and those that can produce more nodes must be given a substantial consideration.

For root length, its strong correlated traits are the weight of the same. Hence, the study recommends that sugarcane plants that can produce heavier and dense roots be a priority in selecting the cane setts to be propagated or be planted in a nursery. Heavier and dense rooting can help in the absorption of sufficient amount of water including the BSS, that undoubtly can enhance the growth of sugarcane tillers. In doing so the planting materials can be increase rapidly with dispatch per unit area.

The researchers suggest that further studies on the effects of different concentrations of bio-stimulant solution on other parameters in sugarcane production especially at the tillering stage. The researchers suggest also that other varieties be included as well and the yield both in tonnage and sugar production (Lkg) should be included as well.

Conflict of Interest

No other group is involved in this study

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